(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
28 June 2001 (28.06.2001)

PCT

(10) International Publication Number
WO 01/45550 A3

(51) International Patent Classification[7]: A61B 17/22

(21) International Application Number: PCT/US00/35262

(22) International Filing Date:
22 December 2000 (22.12.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/171,703 23 December 1999 (23.12.1999) US

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(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

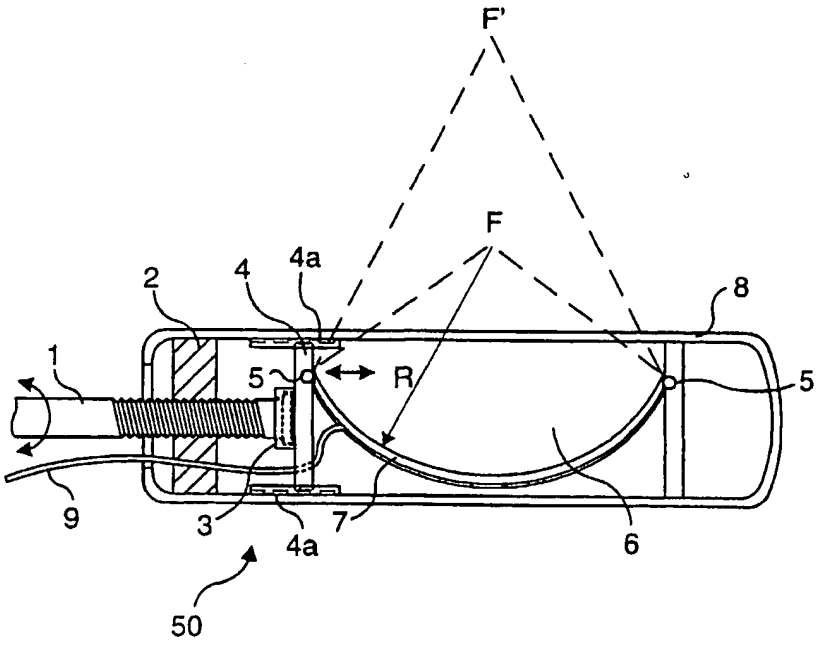
(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

(88) Date of publication of the international search report:
13 December 2001

[Continued on next page]

(54) Title: ULTRASOUND TRANSDUCERS FOR IMAGING AND THERAPY



(57) Abstract: Ultrasound applicators able to both image a treatment site and administer ultrasound therapy include an array of transducer elements (102) that can be focused. In several embodiments, an electronically phased array (102) is used for controlling the focal point of an ultrasound beam. The ultrasound beam produced thereby can also be electronically steered. To reduce the quality factor or Q of the array (102) when the array (102) is used for imaging, an electronic switch (171) is selectively closed, placing a resistance in parallel with each of the array elements (102). A flexible array (102) is employed in several embodiments and is selectively bent or flexed to vary its radius of curvature and thus control the focal point (132) and/or a direction of focus of the array (102). In another embodiment, each of the transducer elements (102) comprising the array (102) are individually mechanically pivotable to steer the ultrasonic beam produced by the transducer elements.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/35262

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : A61B 17/22
US CL : 600/439

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 600/439; 601/2-4

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4,957,099 B1(Hassler) 18 September 1990, see entire document	43-49
A,P	US 6,182,341 B1 (Talbot et al.) 06 February 2001, see entire document	1-60
A	US 5,243,988 B1 (Sieben et al.) 14 September 1993, see entire document	1-60
A	US 5,738,635 B1 (Chapelon et al.) 14 April 1998, see entire document	1-60
A	US 4,484,569 B1 (Driller et al.) 27 November 1984, see entire document	1-60

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search
23 April 2001 (23.04.2001)

Date of mailing of the international search report
28 JUN 2001

Name and mailing address of the ISA/US
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Form PCT/ISA/210 (second sheet) (July 1998)

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Published:
— *with international search report*
— *with amended claims*

[Continued on next page]

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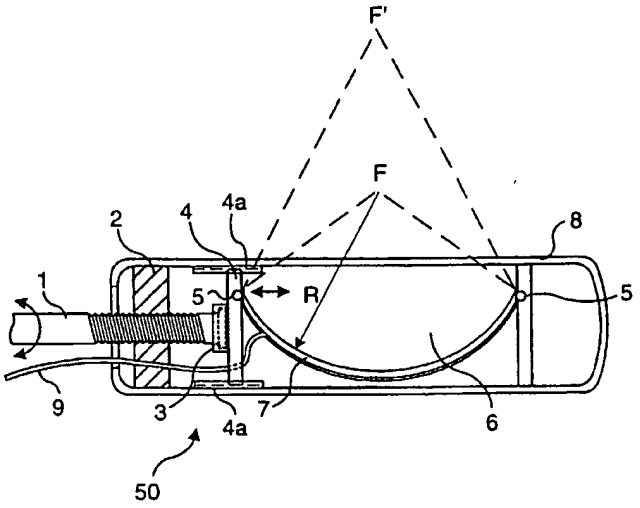

(57) Abstract: Ultrasound applicators able to both image a treatment site and administer ultrasound therapy include an array of transducer elements (102) that can be focused. In several embodiments, an electronically phased array (102) is used for controlling the focal point of an ultrasound beam. The ultrasound beam produced thereby can also be electronically steered. To reduce the quality factor or Q of the array (102) when the array (102) is used for imaging, an electronic switch (171) is selectively closed, placing a resistance in parallel with each of the array elements (102). A flexible array (102) is employed in several embodiments and is selectively bent or flexed to vary its radius of curvature and thus control the focal point (132) and/or a direction of focus of the array (102). In another embodiment, each of the transducer elements (102) comprising the array (102) are individually mechanically pivotable to steer the ultrasonic beam produced by the transducer elements.

WO 01/45550 A3

(88) **Date of publication of the international search report:**
13 December 2001

Date of publication of the amended claims: 30 May 2002

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AMENDED CLAIMS

[received by the International Bureau on 27 July 2001 (27.07.01);
original claims 44 and 49 amended; remaining claims unchanged (2 pages)]

41. The flexible ultrasound transducer of Claim 40, further comprising a key having a plurality of surfaces that act upon the plurality of pins to define the curvature of the array and thus, the focal point of the array.

42. The flexible ultrasound transducer of Claim 41, wherein the plurality of surfaces of the key are cam shaped and wherein the key is adapted to vary the position of the pins and thereby, to vary the focus of the array as the key is moved.

43. A method for selectively controlling at least one of a direction in which an ultrasound beam is emitted by an ultrasound transducer and a focus point of the ultrasound transducer, comprising the steps of:

(a) providing a flexible transducer array that includes a plurality of ultrasound transducer elements supported on a flexible layer;

(b) energizing the plurality of ultrasound transducer elements so that they emit an ultrasound beam; and

(c) enabling a user to selectively cause the flexible transducer array to bend so that the flexible transducer array assumes a curvature that achieves at least one of a desired direction and a desired focal point for the ultrasound beam emitted by the plurality of ultrasound transducer elements.

44. An ultrasound transducer that emits an ultrasound beam toward at least one of a desired direction and a desired focal point, comprising:

(a) a plurality of separate ultrasound transducer elements that are pivotally mounted in a spaced-apart array; and

(b) a plurality of actuators coupled to the plurality of ultrasound transducer elements and adapted to independently selectively rotate the plurality of separate ultrasound transducer elements about an axis of each, thereby orienting each of the plurality of separate ultrasound transducer elements so that it is directed in a desired direction, and so that when energized, the plurality of separate ultrasound transducer elements collectively emit an ultrasound beam toward at least one of a desired direction and a desired focal point.

45. The ultrasound transducer of Claim 44, wherein each of the plurality of actuators includes a prime mover and a linkage coupled to one of the plurality of separate ultrasound transducer elements.

46. The ultrasound transducer of Claim 44, further comprising a housing in which the plurality of separate ultrasound transducer elements are disposed.

47. The ultrasound transducer of Claim 44, further comprising a plurality of leads separately coupled to each of the plurality of separate ultrasound transducer elements to provide a driving signal thereto.

48. The ultrasound transducer of Claim 44, wherein each of the plurality of separate ultrasound transducer elements comprises a composite mixture that includes a piezo ceramic, an adhesive binder, and thermally conductive particles.

49. A method of mechanically controlling at least one of a desired direction and a desired focal point of an ultrasound beam emitted by a plurality of separate ultrasound transducer elements, comprising the steps of:

(a) providing a plurality of separate ultrasound transducer elements that are pivotally mounted to rotate when actuated, each of the plurality of separate transducer elements being independently pivoted by its own actuator;

(b) actuating the plurality of separate ultrasound transducer elements so that each emit an ultrasound signal; and

(c) selectively rotating the plurality of separate ultrasound transducer elements about their respective axes so that the ultrasound signals they produce are combined in an ultrasound beam that is directed toward at least one of a desired direction and a desired focus.

50. An ultrasound applicator that is capable of both ultrasound imaging and administering ultrasound therapy to a site, comprising:

(a) a ultrasound transducer mounted in a housing;

(b) a plurality of conductors adapted to couple a control system to the ultrasound transducer, for conveying signals that energize the ultrasound transducer in one of an imaging mode and a therapy mode; and

(c) a quality factor circuit adapted to couple to the control system and connected to the ultrasound transducer, said quality factor circuit including a switch that is selectively actuated to vary a quality factor associated with the ultrasound transducer based upon whether the ultrasound transducer is operated in the imaging mode or the therapy mode.

51. The ultrasound applicator of Claim 50, wherein the ultrasound transducer is configured in a concave curved shape.